Revolutionary flow measurement concept for the Pharmaceutical industry

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Fluid flow measurement technology is designed to improve productivity and provide crucial information for manufacturing processes. Within the Pharmaceutical industry it is also required to perform to exacting standards relating to hygiene, purity and accuracy that will meet both internal targets and the regulatory requirements. Liquid flowmeters are used throughout pharmaceutical processes, with the majority of the high specification meters being used in the production of the Active Pharmaceutical Ingredient (API). All of these flowmeters have limitations leading to designers having to make a compromise in many cases.

The need to improve this situation has led to the development of an existing technology (Surface Acoustic Wave) and its use to provide a solution to meet the requirements of the highly demanding Pharmaceutical industry.

Notice: This article looks at the measurement of liquids and does not aim to discuss flow measurement in steam or other gases.

Existing technology

Flow measurement devices, from the most basic paddle wheel to an advanced Coriolis flowmeter, all have one or more constraints that can limit the application in which they can be used. Many employ moving parts that are in contact with the fluid, which can cause a flow restriction as well as reducing the efficacy of the hygienic cleaning process. The demand for more advanced, non-contact measurement technology has seen the rise in ultrasonic and Coriolis technology and each of these have their place. However, even these devices have limitations including measuring non-conducting liquids or those containing bubbles or debris. Ultimately it may be the location, space or orientation that may determine the most suitable design for a particular application.

Ultrasonic devices use either the Doppler Effect or transit time measurements to determine the flow of gasses and liquids. However, despite the high initial cost of these designs, the Doppler Effect versions cannot be used with pure fluids since they require the particulate material or bubbles to reflect the signal; conversely, the transit time devices can only be used with pure fluids. It is possible to use combination units that assess the fluid conditions and then select the measurement operation as required; however, there is an additional cost implication with this selection. Furthermore, the accuracy of ultrasonic flowmeters can decrease in low flow situations.

The principle of operation of magnetic flowmeters is based on Faraday's Law of Electromagnetic Induction, where the voltage measured is proportional to the velocity of the flow. This can lead to reduced accuracy with reduced flow velocity. Magnetic flowmeters rely on the fluid having conductive properties to a greater or lesser degree depending on the individual design; however, applications involving hydrocarbons or de-ionised water are not viable. An added complication is that the installation of magmeters normally requires the pipe to be grounded using specific procedures, which can increase the complexity of the installation. Failing to complete this properly can result in fluctuating signals. Furthermore, magnetic flowmeters also rely on the fluid being free of any entrained bubbles in order to provide reliable and consistent readings.

Coriolis flowmeters are regarded as the top specification flowmeter due to their versatile capabilities for both fluids and gases. However, the initial cost of such devices can be very high and they do have some constraints. The design of the Coriolis flowmeter causes a pressure loss across the flowmeter and this can affect the upper limit of the measurement range. The pressure loss increases with flowrate and the corresponding velocity through the meter.

Additionally, the size and weight of the Coriolis flowmeter requires it to be carefully supported within the process pipework. The space required for Coriolis flowmeters is greater than that required for the designs discussed so far with additional pipe supports and installation time required. In terms of liquid flow measurement, there is a clear opening for a device which can deliver a compact, non-contact measurement which is accurate irrespective of media characteristics, flow direction and flow conditions.

New Technology explained

Surface Acoustic Waves (SAW) were first discovered in 1885 and their properties have been examined for many years, with a great deal of modern technology using the principle. Part of that research has led to the development of a fluid flow measuring sensor by Bürkert Fluid Control Systems, which aims to deliver every requirement of a hygienic, accurate and reliable flowmeter, without the constraints that affect traditional flowmeters, including cost.

The main principle of this flow measurement system is based on wave propagation forms similar to seismic waves, which start from an initial point of excitation and spread along the surface of a solid material. Interdigital transducers, which are located on the outside of the measuring tube, are used as both senders and receivers of the waves. The physical design of this revolutionary flow measurement system means that the sensor part is not in direct contact with the fluid, the first of many advantages.

Figure 1. Shows a transducer (1) emitting the wave, part of which travels directly to the first receiver (2). The signal also travels across the liquid and propagates to the opposite side of the tube, where it couples into the tube again and propagating on the surface to the next receiver (3). Again, as before, the signal couples out to the liquid running to the opposite side of the tube where the process repeats itself. Thus, a single excitation leads to a sequence of signals being received by two other transducers.

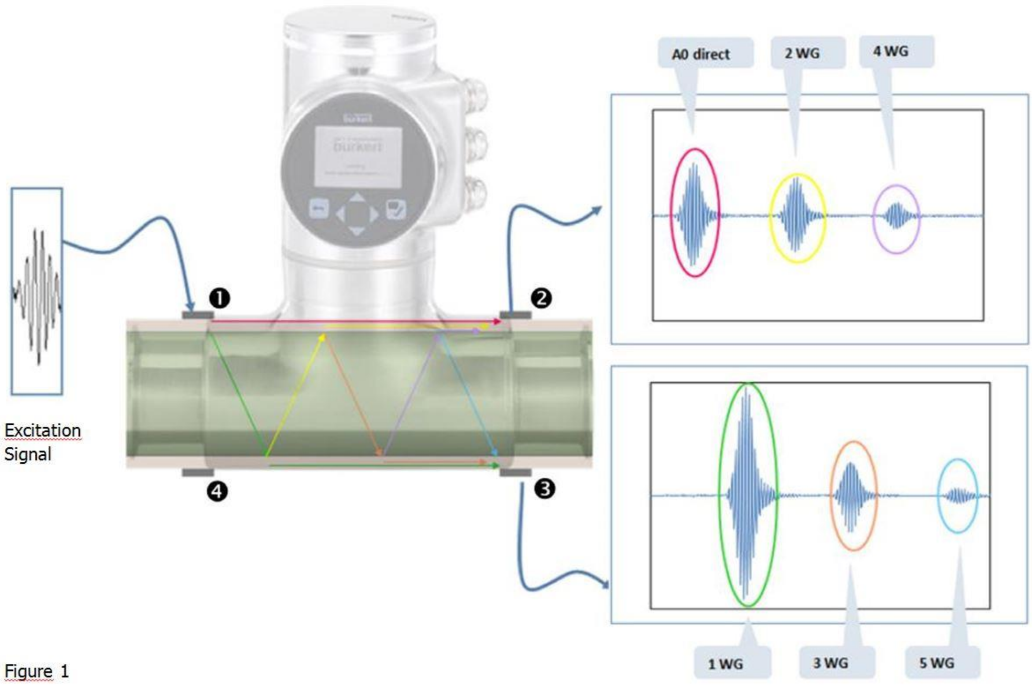

Figure 1

The absolute time for the wave to travel from the sender to the receiver depends mainly on the tube diameter and the type of liquid. The difference between the time of propagation in the forward and backward direction is proportional to the flow. The analysis of all the signals and comparisons based on different criteria such as amplitude, frequency and time of flights, allows evaluation of the quality of the measurement as well as the kind of liquid and its properties.

The angle with which the waves couple out of the liquid is dependent on the velocity of the wave on the tube surface and the velocity of the wave in the liquid. An ‘acoustic fingerprint’ of the medium is created by combining this with the reception signal characteristics, which depend on whether the signals have passed through the medium singly or multiply. From this, the volume flow rate, density and temperature and so mass flow rate can be determined, as well as additional information about the medium itself. Since the technology requires no elements within the pipe, the diameter and therefore the flow resistance remain unchanged.

Technology development

Bürkert partnered with a company, which had already developed SAW technology for concentration measurement for mainly laboratory use, for the research work to verify SAW for inline flow measurement. In addition to that Bürkert transferred the result into a commercially available product designed for industrial usage. The development of this technology into a proven flow measurement device for liquids has therefore been undertaken by Bürkert and the end result is a new flowmeter with cutting-edge technology, which has been named FLOWave.

FLOWave also solves many of the issues associated with some high-end flowmeters, such as system vibration in the plant, magnetic and electrical effects as well as the non-conductivity of the liquid - none of these factors have any effect on the accuracy or reliability of the flow measurements.
In addition, the SAW technology also has the ability to distinguish between laminar and turbulent flows without secondary sensing technology. It is also highly energy efficient, an aspect of any product which is becoming increasingly important today.

SAW flow measurement advantages

In common with several other designs, SAW based inline flowmeters have no direct contact with the fluid, which means there is no pressure drop and no restriction in flow, but the measurement principles of SAW allow it to overcome the shortcomings of other, similar, flowmeters. The principles behind this design enable the flowmeter to work with a stagnant liquid and so reliable flow figures are available even for the smallest flow volumes. The technology also enables it to recognise quick flow changes reliably, which makes it suitable for fast filling processes as well.

The technology does not depend on the conductivity of the fluid, allowing it to perform accurately on a wider range of fluids compared to magmeters. Neither is it affected by, or requires, entrained bubbles or debris to deliver consistent, repeatable readings, which may be the case when using other, more traditional measurement devices. FLOWave is designed to offer a modular device that can be specified to deliver the exact requirements of a particular process with excellent flexibility to allow future expansion. Due to the wide range of applications that are suitable for FLOWave measurement, and the simplicity of its design, there is considerably less effort required in specifying the correct device for a particular application.

The actual installation process is significantly less complicated when using a FLOWave device as it can be mounted in any orientation and it requires a great deal less space that similar devices using more traditional measurement techniques. The FLOWave can also be specified with or without a display module that can be positioned to suit the final orientation in the process pipework. Furthermore, once installed, the FLOWave range offers ongoing benefits including a device status indicator which provides diagnostic status information to the operator, as outlined by NAMUR NE107. In addition, this technology requires considerably less energy to operate; approximately one third of that required by a standard Coriolis flowmeter.

In situations where a choosing between minimising contamination and maximising accuracy is not acceptable, selecting the latest innovation in liquid flow measurement may be the best method of gaining the benefits of both criteria.

Benefits to the Pharmaceutical industry

Flow measurement is used throughout the production of the Active Pharmaceutical Ingredient (API), with a requirement to deliver high accuracy, cleanability and reliability. Many of the devices used currently are of the Coriolis design. However, considerable cost savings can be made by examining the benefits of FLOWave without compromising the specifications of the pharmaceutical production lines. The foremost asset of FLOWave is that no sensor parts are inside the measurement tube and the internal surface of the tube. Furthermore, it can be manufactured to the same surface finish as the rest of the pipeline, meaning that, in terms of hygiene, cleaning and flow conditions, there is no difference to any other piece of straight pipe. The non-contact nature of the design brings the hygiene benefits that are seen in high specification flowmeters, except without the additional cost premium.

Not only does this revolutionary design come in a compact and simple design, but this flowmeter can also be installed in horizontal and vertical applications without affecting performance. When producing or using clean water used for drug production or for intravenous injection, flow measurement cannot be achieved by magmeters due to the low conductivity of very pure water. For example, its use in medical care, anesthesia, cardiology, intravenous infusion, kidney dialysis and other areas of medicine requires metering.

This sector is a highly demanding market when it comes to the specification of instrumentation making the high accuracy of the SAW based flowmeter ideally suited. Typical applications are expected to include: metering of costly purified water use, mixing intravenous infusions, fluids for dosing systems and monitoring of medicine production, plus, many flow and temperature monitoring applications for critical CIP and SIP processes both in manufacturing and in medical care delivery situations.

FLOWave specifications

As one of the leading manufacturers of process control and measuring equipment, Bürkert has included the high levels of accuracy and reliability along with the usual build quality and connectivity options. Using the industry standard of 24 VDC supply, the FLOWave device can provide both analogue and digital outputs with excellent temperature and flow measurement accuracy.

The SAW sensor is connected to the transmitter which comprises the user interface and generates the required output signals. The transmitter is based on Bürkert's new electronic platform called EDIP, which is fully modular and uses digital communication between the sub-assemblies. The design uses CAN open with extensions, allowing to establish complete network topologies which enables Bürkert to offer customers ready-made solutions with complete flexibility and customised to their exact requirements.

The initial design, Type 8098, will comprise an all stainless steel body in four sizes, DN15 (1/2"), DN25 (1"), DN40 (11/2") & DN50 (2"), fitted with a clamp connection to ASME, DIN or ISO standards and a tube inner surface finish up to 0.4µm to meet hygienic standards. There will be an option to select either with or without an HMI module (a display including operation keys) which can be placed on the top or on the front of the flowmeter and which may be rotated through 90° steps to suit the installation.

Conclusions

Flow measurement in a variety of fluid conditions can improve overall product quality, consistency and process efficiency as well as reducing waste of expensive ingredients. The more advanced, non-contact, flow measurement technologies, such as ultrasonic, electro-magnetic and Coriolis sensors, still have limitations. The flow characteristics, media purity and space constraints of most current flowmeters can be determining factors in deciding which design is best suited to a particular application.

Bürkert has looked to address all of these issues in the creation of a new flowmeter design which has the potential to transform the market in terms of liquid flow measurement. Through the development of existing technology and the use of advanced electronics, Bürkert has delivered a revolutionary method of liquid flow measurement that can be employed in a wide range of applications. The FLOWave range has unparalleled diversity in terms of application while still delivering the highest standards in materials technology and hygienic approvals. Further development of the product will improve its capabilities with the ability to measure density and thereby mass flow values.

Process design engineers now have a more simplified selection procedure when it comes to specifying flowmeter technology, especially for applications that are aiming to maintain high standards of hygiene, improve installation efficiency and reduce energy consumption.

Contact

Do you have questions or can we show you our newest controlling technology? Just contact

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